



Browne, D. T., Wade, M., Plamondon, A., Leckie, G., Perlman, M., Madigan, S., & Jenkins, J. M. (2018). Child and contextual effects in the emergence of differential maternal sensitivity across siblings. *Developmental Psychology*, 54(7), 1265-1276. <https://doi.org/10.1037/dev0000506>

Peer reviewed version

Link to published version (if available):
[10.1037/dev0000506](https://doi.org/10.1037/dev0000506)

[Link to publication record in Explore Bristol Research](#)
PDF-document

This is the author accepted manuscript (AAM). The final published version (version of record) will be available online via APA. Please refer to any applicable terms of use of the publisher.

University of Bristol - Explore Bristol Research

General rights

This document is made available in accordance with publisher policies. Please cite only the published version using the reference above. Full terms of use are available:
<http://www.bristol.ac.uk/pure/about/ebr-terms>

Running Head: DIFFERENTIAL SENSITIVITY

Child and contextual effects in the emergence of differential maternal sensitivity across siblings

Dillon T. Browne

California School of Professional Psychology, San Francisco

Mark Wade

Boston Children's Hospital, Harvard University

Andre Plamondon

Department of Education, Laval University

George Leckie

Center for Multilevel Modeling, University of Bristol

Michal Perlman

Department of Applied Psychology and Human Development, University of Toronto

Sheri Madigan

Department of Psychology, University of Calgary

Jennifer M. Jenkins

Department of Applied Psychology and Human Development, University of Toronto

Correspondence concerning this article should be addressed to Dillon Browne, California School of Professional Psychology, San Francisco, 1 Beach St, San Francisco, CA, 94133. BrowneDT@gmail.com, 1-415-905-0009. Other Authors: Mark Wade (wadem2@gmail.com), Andre Plamondon (andre.plamondon@gmail.com), George Leckie (g.leckie@bristol.ac.uk), Michal Perlman (michal.perlman@utoronto.ca), Sheri Madigan (sheri.madigan@ucalgary.ca), Jennifer M. Jenkins (jenny.jenkins@utoronto.ca)

Running Head: DIFFERENTIAL SENSITIVITY

Child and contextual effects in the emergence of differential maternal sensitivity across siblings

Abstract

The present study examined the effects of socioeconomic status (SES) and sibling differences in birth weight on sibling differences in the receipt of maternal sensitivity (i.e., differential parenting). It was hypothesized that sibling differences in birth weight would predict *absolute* differential parenting across the sibship (i.e., the more different siblings' birth weight, the more different the level of sensitivity in the family, overall) and *child-specific* differential parenting (i.e. relatively heavier siblings receiving more sensitivity, compared to his/her counterpart within the family). It was also hypothesized that there would be greater sibling differences in birth weight in lower SES settings. Multiparous mothers were recruited within two weeks of childbirth and filmed interacting with each of their children when younger siblings were 1.60 years ($SD = .16$, $N=396$ younger siblings) and next-older siblings were 4.05 ($SD = .75$; $N = 396$ older siblings). Videotapes were coded for maternal sensitivity. Multilevel path-analysis revealed that lower-SES families exhibited greater sibling differences in birth weight, which corresponded to greater absolute differential parenting. Also, heavier siblings received relatively higher levels of sensitivity within the family. This study demonstrates that child and contextual factors operate together in predicting differential parenting.

Keywords: siblings; socioeconomic status; birth weight; maternal sensitivity; differential parenting

Sibling differences in the receipt of sensitive parenting (i.e., *differential parenting*) predict child outcomes beyond the absolute level of parenting (Meunier, Boyle, O'Connor, & Jenkins, 2011). At least a third of the variability in maternal sensitivity differs across siblings (Avinun & Knafo, 2013; Klahr & Burt, 2014). There remains a paucity of literature in this area, as most studies have focused on determinants of parenting specific to single mother-child dyads, as opposed to multiple dyads within the family. A clear understanding of developmental processes within the family can only emerge when multiple siblings are examined (Browne, Plamondon, Prime, Puente-Duran, & Wade, 2015). Thus, the current study harnesses the strengths of a sibling comparison design to examine how child and contextual factors may be associated with differential parenting.

Belsky's (1984) influential *determinants of parenting model* suggests that individual differences in parenting (e.g., maternal sensitivity) are at least partially attributable to the characteristics of children (Belsky & Jaffee, 2015). Beginning early in life, variation in child biobehavioral regulation may differentially elicit sensitive responses from caregivers (Bell, 1968; Granic & Patterson, 2006), which in turn become important influences on development (Plamondon, Browne, Madigan & Jenkins, 2017; Sameroff, 2010). Presently, there is a paucity of literature that considers "child effects" in the emergence of differential parenting (Jenkins, McGowan, & Knafo-Noam, 2016). Yet it is plausible that sibling differences in biological risk (e.g., lower birth weight) predict sibling differences in the receipt of sensitive caregiving. In other words, siblings may be treated differently according to characteristics that differ between them. Belsky's model also posits that broader contextual characteristics relate to variation in parenting quality, often indirectly through proximal factors such as child characteristics. However, it remains unclear whether environmental factors (e.g., low socioeconomic status;

SES) increase sibling differences in maternal sensitivity, either directly or indirectly through child characteristics. Thus, the present study employs a sibling comparison design to explore (1) the effects of birth weight and SES on differential maternal sensitivity, and (2) the indirect effects of SES on differential maternal sensitivity via sibling differences in birth weight.

Why Consider Siblings in the Study of Parenting?

Given that many children are raised alongside siblings, it is important to consider processes that are operative for entire families versus particular children (Browne et al., 2015; Plomin, 2011). For example, sibling differences in the receipt of parenting (including sensitivity) can drive developmental outcomes – a phenomenon known as differential parenting or parental differential treatment (Atzaba-Poria & Pike, 2008; Henderson, Hetherington, Mekos, & Reiss, 1996; Jenkins et al., 2003). Differential parenting is deleterious for disfavored children in terms of learning and behavior (Asbury et al., 2006), socioemotional problems (Burt, McGue, Iacono, & Krueger, 2006; Meunier, Boyle, O'Connor, & Jenkins, 2013), personality, temperament, (Turkheimer & Waldron, 2000), and general health (Browne & Jenkins, 2012). Moreover, there is evidence to suggest that differential parenting is harmful for all children within a family, possibly due to the creation of a negative emotional climate or sibling contagion (Boyle et al., 2004; Feinberg et al., 2003; Meunier, Bisceglia, & Jenkins, 2012).

Another reason it is important to consider multiple siblings in the study of parenting has to do with the effects of adversity across the entire family system. Indeed, Plomin (2011) notes that factors shared by children (e.g., low SES) partially influence development by increasing variation in environments that are unique to particular children within the family (i.e., making siblings more different). A number of studies have demonstrated that differential parenting is higher under settings of low SES (Browne, Meunier, O'Connor, & Jenkins, 2012; Browne et al.,

2015; Henderson et al., 1996; Jenkins et al., 2003). Here, the idea is that economic pressures reduce parental psychological resources and cause stress. Consequently, parents will allocate their limited time, warmth, and affection to a child who is easier or more rewarding to parent. Currently, the role of child effects in linking SES and differential parenting is unclear.

Examining patterns of association between child and contextual factors on parenting within a multi-level framework offers several advantages over studies that assess single mother-child dyads (see Browne et al., 2015; Jenkins et al., 2016). First, family processes and developmental outcomes unique to particular children can be disambiguated from those common to all children in a household. When each child has a unique value on a given variable (as is the case in birth weight and maternal sensitivity) measurements can be decomposed into three values: (1) family average, reflecting the mean of all children's scores in the family, (2) absolute difference, reflecting the magnitude of differences in scores within a family, and (3) child-specific, reflecting a child's relative difference from the family mean. The family average and absolute difference are *between-family factors*, given that there is only one score-per-family. Associations at this level reveal how families differ from one another. The child-specific score is a *within-family factor* since each child has his or her own score. Associations at this level reveal how children within the same family differ from one another. Second, associations amongst family processes and child outcomes can be disambiguated across these levels of organization. For example, one could explore if family-wide contextual risks impact all children in a family similarly (i.e., it makes children from the same family more similar than two children from different families), or if it makes siblings within the same family different from one another. Finally, such methodology permits the robust testing of associations amid child-specific predictors and outcomes, eliminating possible confounding at the family-wide level (i.e., sibling

comparison design). Studies that follow only one child per family are not able to disambiguate the association between child characteristics and parenting from family-wide risk. By comparing siblings within the same family, we are able to eliminate the possibility that background heterogeneity (before the parental generation) accounts for the observed relationship, thereby increasing internal validity (Frisell, Öberg, Kuja-Halkola, & Sjölander, 2012). There have been calls for family-based designs that permit the isolation of these processes (D’Onofrio, Lahey, Turkheimer, & Lichtenstein, 2013; Lahey & D’Onofrio, 2010), including the study of child effects on parenting in the context of adversity (Browne et al., 2015; Jenkins et al., 2016).

Sibling Differences in Birth Weight and Differential Maternal Sensitivity

If child characteristics influence the caregiving environment (Bell, 1968; Belsky, 1984; Belsky & Jaffee, 2015; Sameroff, 2010), one must consider how sibling differences in the same characteristics influence differential parenting (Jenkins et al., 2016). Between-family studies have drawn connections between birth weight and maternal sensitivity (Camerota et al., 2015), in which children with higher birth weight show more advanced behavioral regulation and neurocognitive development (Asbury, Dunn, & Plomin, 2006; Conley & Bennett, 2000; Jefferis, Power, & Hertzman, 2002; Madigan, Wade, Plamondon, Browne & Jenkins, 2015). These children appear better adjusted and easier for mothers to read, resulting in higher levels of sensitivity, attunement, reciprocity, and positivity during interactions (Feldman, 2006). Extended to the family system, this implies that siblings who are highly variable in terms of birth weight elicit more variable responses. It is unclear, however, whether these associations reflect *absolute* sibling differences (e.g., greater sibling differences in sensitivity, overall, when siblings are more different in birth weight) or *child-specific* sibling differences (e.g., relatively heavier children

receiving more sensitivity compared to his or her sibling). Clarification of this mechanism may improve our understanding of the determinants of parenting in the family context.

Maternal responses to individual child differences have been considered under the framework of resource allocation (Becker & Tomes, 1994; Gaviria, 2002). To date, “resources” have been broadly measured via self-report metrics of material investments or parent-child relationship quality. Conversely, other studies have employed proxy metrics of resource allocation, including breastfeeding, school attendance, medical care, and duration of parent-child contact (Lynch & Brooks, 2013). Notably, self-report measures are subject to recall and personal bias, and may be more reflective of parental attitudes and beliefs than actual behavior during real-time interactions (Gardner, 2000). Similar validity concerns have been raised for retrospective recall of psychosocial and material resources (Henry, Moffitt, Caspi, Langley, & Silva, 1994). To date, no study has prospectively examined the association between sibling differences in birth weight and parenting using observational measures, which provide a more objective assessment of behavior (Gardner, 2000). This is a stark omission in the developmental literature given the plethora of literature citing contingency between mother and child responding during interactions (e.g., Feldman, 2012). Thus, the present study sought to explore this issue using an intensive observational coding system of maternal sensitivity.

Maternal sensitivity is a suitable metric of parental resource allocation given the complex and demanding nature of this phenomenon and its association with developmental success in a number of areas. These include emotion/anger regulation (Feldman, Dollberg, & Nadam, 2011; NICHD, 1999), joint attention and attentional control (Belsky, Pasco Fearon, & Bell, 2007), early communication (Gunning et al., 2004), cognitive development (Bernier, Carlson, Deschênes, & Matte-Gagné, 2012), adrenocortical and other physiological responses (Feldman,

2006; Sethre-Hofstad, Stansbury, & Rice, 2002), compliance to caregivers (Feldman & Klein, 2003), and attachment security (Belsky & Fearon, 2002; NICHD, 2001). Given that heavier siblings exhibit fewer behavior problems (Asbury et al., 2006), and siblings with fewer behavior problems experience more sensitivity (Browne et al., 2012), we hypothesized that heavier infants would receive more sensitivity.

SES and Sibling Differences in Birth Weight

What sorts of environments give rise to the hypothesized relationship between sibling differences in birth weight and differential maternal sensitivity? Following the determinants of parenting framework and discussion of contextual effects on parenting (Belsky, 1984, Belsky & Jaffee, 2015), in addition to the effects of socioeconomic status on differential parenting (Jenkins et al. 2003), we considered the potential influence of SES on sibling differences in birth weight. Between-family studies clearly indicate that birth weight is predicted by SES (Finch, 2003). Moreover, it differs within women and across pregnancies (Lunde, Melve, Gjessing, Skjærven, & Irgens, 2007). Environmentally-induced sibling variation in biological ontogenesis is evident as early as fetal development (Gluckman et al., 2010; Lunde et al., 2007). Siblings who experience more favorable *in utero* environments – indexed by maternal weight gain during pregnancy – grow more during gestation and are heavier at birth, irrespective of genetic effects (Hutcheon, Platt, Meltzer, & Egeland, 2006; Ludwig & Currie, 2010). Yet no studies have tested for *increased* sibling differences (i.e., absolute differences in birth weight) under low SES.

Measured environmental effects on birth weight may be the same or different for siblings (de Bernabé et al., 2004; Dubay, Joyce, Kaestner, & Kenney, 2001; Kearney, Munro, Kelly, & Hawkins, 2004). There are some environmental influences that likely persist across multiple pregnancies (e.g., persistent poverty, access to prenatal care and universal healthcare), and

factors that could potentially differ (e.g., maternal nutrition, placenta functioning, smoking, pregnancy stress, and maternal mental health). Importantly, family risks that are the same for all siblings can operate to increase the amount of sibling differences in risk exposure (Browne et al., 2015; Plomin, 2011). Indeed, it has been suggested that certain factors may increase differences in environmental influences across pregnancies, including the presence of a new partner or family reconstitution between births (Lunde et al., 2007).

Given that family dysfunction and health behaviors are associated with broad contextual influences such as SES (Bradley & Corwyn, 2002), it is conceivable that low family SES serves to increase absolute sibling differences in fetal environments and birth weight. Indeed, the tenuous and unpredictable nature of economic disadvantage may lead to differential resourcing of children during gestation (Hutcheon et al., 2006). While low SES is often conceptualized as chronic and persistent, there is also evidence to suggest that low SES families experience bouts of stress that may coincide with relatively acute events, including workplace challenge, job and food insecurity, and periods of marital strife (Brooks-Gunn, Schneider, & Waldfogel, 2013; Repetti, Wang, & Saxbe, 2009). Thus, the effects of SES on maternal functioning during the peripartum period may not be equivalent for all children in a family. As a result, in the context of multiple pregnancies over time, it is possible that economic deprivation will have differential effects on siblings' development during *in utero* growth. Thus, the present study first sought to examine the link between SES and absolute sibling differences in birth weight. Such effects would presumably be over-and-above the effects of SES at the family level, whereby all siblings in a family have lower birth weight, on average, due to shared environmental risks (Finch, 2003).

The Current Study

The current study tests the following four hypotheses in a single multilevel path model using a prospective birth cohort of families: (1) lower family SES will be associated with greater absolute sibling differences in birth weight; (2) absolute sibling differences in birth weight will predict absolute differential parenting, overall (i.e., greater magnitude of differential maternal sensitivity); (3) SES will be associated with absolute differential sensitivity via sibling differences in birth weight; and (4) relatively heavier siblings will experience greater levels of maternal sensitivity within families (i.e., child-specific differential sensitivity), irrespective of unobserved between-family confounds (i.e., the sibling comparison component).

Methods

Participants and Data

Multiparous women giving birth to infants in the cities of Toronto and Hamilton between 2006 and 2008, who had been contacted by the *Healthy Babies Healthy Children (HBHC)* public health program (run by Toronto and Hamilton, Ontario, Public Health Units), were considered for participation. Inclusion criteria for the intensive sample of Kids, Families Places (KFP) were as follows: (1) English-speaking mother; (2) a newborn weighing at least 1500g; (3) two or more children less than 4 years old in the home; and (4) agreement to the collection of observational and biological data. Children under 1500 grams (i.e., “very low birth weight”) were excluded from the KFP study, given that this group of children is medically complex, presents with numerous neurodevelopmental challenges, and represents a small percentage of total births in the population (1.3%; Kowlessar et al., 2013). As the KFP study is an epidemiological cohort concerned with the various psychosocial and genetic influences on development, this group was removed from the sampling frame in order to avoid bias in patterns of association across the entire sample. Readers should not generalize findings from this study to families of children who

are very low birth weight. Thirty-four percent of mothers whose information was passed by HBHC consented to participate in the study. Reasons for non-enlistment included inability to contact families, ineligibility once contacted, and refusals. Multiparous mothers were exclusively recruited given that the present investigation was concerned with family-wide and child-specific influences on child development.

The University of Toronto Research Ethics Board approved all procedures, including informed consent. We compared our initial sample ($N=501$) with the general population of Toronto and Hamilton using 2006 Census Data, limiting the census to women between 20-50 years and having at least one child. Families were compared on immigrant status, number of persons in the home, family type, maternal income, and educational level. Families were of similar size ($M = 4.52$, $SD = 1.01$ vs. $M = 4.13$, $SD = 1.22$) and maternal income (median C\$30,000–39,999 vs. census population $M = C\$30,504$, $SD = C\$37,808$). As our sample was recruited so shortly after childbirth, there are fewer non-intact families than in the population (5% vs. 16.8% lone-parent families; 4.3% vs. 10.3% stepfamilies). The proportion of Canadian born to immigrants was somewhat higher in the current sample (57.7% vs. 47.6%), likely due to the language requirement for participation. Also, more study mothers had earned a bachelor's degree or higher (53.3% vs. 30.6%). Of participating mothers, 56.5% self-identified as being of European descent, 14.6% as South Asian, 9.3% as Black, 12% as East Asian and 8.6% as other.

In the KFP Study, 74.1% of families were 2 child families, 18.8% were 3 child families, and the remaining 7.2% had 4 or more children. To minimize burden on families we only collected observational data on the target child and the next in age older sibling. Demographic measures and SES were measured at baseline when younger children were newborns ($M_{\text{age}} = 2.0$ months, $SD = 1.06$) and older children were on average 2.58 years ($SD = 0.76$); 49% of children

were female. At follow-up, the mother and children were filmed interacting when the target child was approximately 18 months ($M_{\text{age}} = 1.60$ years, $SD = 0.16$), and the older child was about 4-years-old ($M_{\text{age}} = 4.05$ years, $SD = 1.05$). Due to attrition, 397 (79%) families remained at this stage of assessment (see analysis section for description of missing data management).

Measures

Socioeconomic Status. SES was created as a composite variable reflecting family levels of income and assets. Parents responded to the following items: “how many rooms do you have in your house”; “Do you own or co-own this home/apartment/unit, even if still making payments: yes =1, no =0”; “Do you own or co-own a car, even if still making payments: yes =1, no =0”. Additionally, parents responded to a question asking parents to identify annual household income on a scale from 1 (‘no income’) to 16 (‘\$105,000 or more’). Consistent with previous studies (e.g. Tucker-Drob, Rhemtulla, Harden, Turkheimer, & Fask, 2011), each of these variables was turned into a z-score and an average was taken so that higher scores were indicative of higher SES. Internal consistency of the scale was good (Cronbach’s $\alpha = .79$.)

Birth weight. Mothers reported on the birth weight of their two children in kilograms and grams. Nationally representative studies have demonstrated that maternal recall of infant birth weight is a suitable proxy for recorded and documented birth weight at the time of birth (Catov et al., 2006; Walton et al., 2000). For example, one Scandinavian record linkage study demonstrated nearly perfect maternal recall of documented weight when children were between 8-11 years, with virtually no difference in accuracy for children who were teens (Adegboye & Heitmann, 2008). Thus, measurement error should be relatively small as mothers reported on birth weight for the youngest child 2 months after birth, and on the next-youngest child when

they were approximately 4 years old. This was done in order to minimize response burden on families at Time 1.

Maternal Sensitivity. Mothers were videotaped interacting with both children (one at a time) for 15 minutes. They were asked to engage in three different tasks, each of which lasted 5 minutes. First, there was a *free play with no toys task*, where mothers were instructed to play with children as they normally would but without any play materials. Second, there was a *structured teaching with toys task*, where dyads were given a pegboard with circles and squares of different colors and instructed to copy a picture. Specifically, mothers were asked to teach their child how to construct the pattern in the picture, where the pattern was intentionally beyond the child's developmental level in order to elicit maternal teaching. Finally, there was a *reading task*, during which the mother was asked to make up a story to a wordless picture book. These tasks were selected in order to assess mothers' capacity to engage the child positively during common tasks of early childhood.

Maternal sensitivity was assessed using the sensitive responding and mutuality scales of the Coding of Attachment Related Parenting scheme (Matias, 2006) and the positive control scale of the Parent-Child Interaction System (Deater-Deckard, Pylas, & Petrill, 1997). Sensitive responding measures the ability of mothers to display awareness of their child's needs, to be sensitive to the child's signals, and demonstrate perspective taking from the child's vantage point. Mutuality is a dyadic code that reflects conversational reciprocity, sharing of affect, joint engagement during tasks, and open physical posture. The positive control scale assesses positive aspects of a mother's style of directing or influencing child behavior, including using praise, explanations, and asking open-ended questions. A composite was computed by averaging the sensitive responding, mutuality and positive control subscales across all tasks. Internal

consistency was Cronbach's $\alpha = .85$ and inter-rater reliability was high ($\alpha = .94$).

Covariates. Within-family analyses controlled for additional child specific confounding variables, including birth order (1=older, 0=younger), age, gender (1=female, 0=male), and preterm status (36 weeks or less = 1, 37 weeks or more = 0). These variables permitted the further isolation of the within-family association between birth weight and sensitivity. Between-family analyses controlled for the number of children in the family and sibship sex composition (same sex = 1, different sex = 0; reported in text for simplicity of figure presentation). Note that our primary findings were not sensitive to the inclusion of preterm status.

Analysis

Multilevel path analysis was employed to examine the between- and within-family associations amongst maternal sensitivity, birth weight, and socioeconomic status. The integration of multilevel modeling and multivariate data analysis has been described at length (Bauer, 2003; Curran, 2003; Mehta & Neale, 2005), in addition to the employment of a sibling comparison design to control for unmeasured, between-family background heterogeneity to test within-family (i.e., child-specific) hypotheses (D'Onofrio et al., 2008; Lahey & D'Onofrio, 2010; Hadd & Rodgers, 2017; Jaffee, van Hulle & Rodgers, 2011). In the present study, data took a two-level structure whereby siblings (Level 1 or the child-specific/within-family level) were nested within families (Level 2 or family-wide/between-family level). First, a null model was estimated, fitting only child-specific and family-wide intercepts. From this model, variance partitioning coefficients were computed that reflect the proportion of family-wide variance to total variance. This conveys the amount of family clustering in variables. Stated differently, the family-wide variance reflects the amount of sibling similarity, while the child-specific variance

reflects the amount of sibling differences for a particular outcome. Next, a multilevel path model was estimated in order to identify the hypothesized associations amongst response variables.

At the family-wide level, SES was hypothesized to predict absolute sibling differences in birth weight, which was hypothesized to predict absolute differential parenting (i.e., sibling differences in the receipt of maternal sensitivity.) Sibling differences were modeled as a family-standard deviation, which reflects the absolute magnitude of sibling differences for either birth weight or maternal sensitivity in a given family. We hypothesized a negative association between SES and sibling differences in birth weight (i.e., lower SES families have siblings who are more different in birth weight.) We also hypothesized a positive association between absolute sibling differences in birth weight and absolute differential parenting (i.e., greater birth weight differences would be associated with greater differential parenting, overall.) Associations were also considered amongst SES and family-average responses. SES was hypothesized to predict higher family-average birth weight, which was hypothesized to predict higher family-average levels of maternal sensitivity. Direct paths were modelled and all indirect pathways were tested for statistical significance using the Delta method (Mackinnon et al, 2002).

At the child-specific level, a sibling comparison model was employed in order to examine the relative association between child-specific differences in birth weight and differential maternal sensitivity within the family (i.e., do heavier siblings receive more or less sensitivity, compared to his or her sibling). This model is a robust test of this association, as it is free of possible between-family confounders such as shared maternal or contextual factors. Such models have been effectively employed to examine the relationship between child-specific environments and outcomes (Hadd & Rodgers, 2017; Jaffee, Van Hulle, & Rodgers, 2011) and in the study of relative sibling birth weight on parental investment (Lynch & Brooks, 2013).

Let $MS_{ij} - \overline{MS}_{.j}$ denote the maternal sensitivity of child i ($i = 1, 2$) in family j ($j = 1, \dots, J$) deviated from their family average level of sensitivity. The within-family effect of birthweight on maternal sensitivity can then be estimated as

$$MS_{ij} - \overline{MS}_{.j} = \beta_1(BW_{ij} - \overline{BW}_{.j}) + \mathbf{X}'_{ij}\boldsymbol{\gamma}_1 + e_{ij},$$

where $BW_{ij} - \overline{BW}_{.j}$ denotes the child-specific difference from family-average maternal sensitivity, \mathbf{X}_{ij} denotes a vector of child-specific covariates including gender, birth order, age and preterm status, and e_{ij} denotes a normally distributed child specific error term. The strength and direction of β_1 will determine if heavier siblings receive more or less maternal sensitivity, *compared to the other sibling*.

Of the initial 501 families in the KFP study, 397 (79%) remained at follow-up. As is often the case in longitudinal research, retained families were of higher SES. Of these 397, target variables were between 77.0% and 99.9% complete. There was one family with missing data on all predictors and outcomes and was therefore excluded for a final study sample of $N=396$. The reported estimates are based on analyses among the final study sample where missingness was handled under the Missing at Random assumption using Full Information Maximum Likelihood estimation. Running the analyses instead on the initial sample of 501 families gives substantively similar results (see Sensitivity Analysis, Results). Model fit is based on the chi-square test of model fit, Root Mean-Squared Error of Approximation (RMSEA), the Comparative Fit Index (CFI), and the between- and within-family Standardized Root Mean Square Residual (SRMR). Analyses were conducted using Mplus 7 (Muthen, 1998-2010).

Results

Descriptive statistics are presented in Table 1. The primary analyses are presented in Figure 1. Based on a null model, Variance Partitioning Coefficients revealed that 31% of the

variance in birth weight was family-wide, while 69% of the variance was child-specific. For maternal sensitivity, 29% of the variance was family-wide and 71% was child-specific. Thus, there was substantial familial clustering in both variables, though the majority of variance reflected sibling differences (which also included measurement error). Next, the hypothesized multilevel path model was fit (see Figure 1). Model fit statistics indicated that the model was a good fit to the data, $\chi^2(2) = 5.07$, $p = .08$, RMSEA = .04, CFI = .99, within-family SRMR = .02, between-family SRMR = <.01

SES and Increased Sibling Differences

At the family-wide level, lower SES was associated with significantly higher absolute sibling differences in birth weight. That is, siblings are more different in their birth weight under settings of lower SES (see Figure 1 & 2). Furthermore, greater sibling differences in birth weight were associated with greater absolute differential sensitivity. In other words, mothers who have children with more different birth weights tend to parent towards their children more differentially, overall. There was no significant direct effect of SES on sibling differences in the receipt of maternal sensitivity. Also, despite the significant α and β paths in the implied mediation model, the indirect effect of family SES on sibling differences in maternal sensitivity via birth weight was not statistically significant, $\alpha\beta = -.01$, $z = -1.41$ $p = .131$, likely due to the relatively small magnitude of the aforementioned effects. Thus, SES is associated with increased sibling differences in birth weight, which is associated with increased differential parenting, though the indirect effect was not significant.

SES and Family-Average Outcomes

Also at the family-wide level, higher SES was associated with significantly higher family-average birth weight. Moreover, higher family-average birth weight was significantly

associated with higher family-average maternal sensitivity. There was also a large and significant direct effect of SES on family-average maternal sensitivity, whereby higher SES was associated with significantly higher family-average sensitivity, irrespective of family-average birthweight. The indirect effect of SES on family-average maternal sensitivity via family-average birth weight was just above conventional levels of significance, $\alpha\beta = .02$, $z = 1.92$, $p = .055$. Note that number of children in the family and sibship sex composition had no significant association with any of the aforementioned between-family (Level 2) pathways.

Child-Specific Associations amongst Birth Weight and Sensitivity

At the child-specific level, siblings served as a source of comparison for one another. This relationship reflects the extent to which a sibling's relative birth weight corresponds to relative differences in the receipt of maternal sensitivity. This association is entirely *within families*. Thus, it necessarily has something to do with sibling differences and is free of confounding at the between-family level (i.e., not due to unobserved factors that differ across families.) As hypothesized, this effect was statistically significant (see Figure 1 & 3), indicating that relatively heavier children at birth receive more maternal sensitivity at 18 months, compared to their lower birth weight siblings. That is, a one standard deviation increment in child-specific birth weight corresponded to maternal sensitivity scores that were over one-tenth of a standard deviation higher, relative to one's sibling. Also, older siblings were substantially more likely to receive higher levels of sensitivity, relative to younger siblings.

Sensitivity Analyses

A number of sensitivity analyses were carried out to assess the robustness of association between study variables. First, to examine the impact of sample selection, all analyses were conducted using FIML to address missingness up to $N = 501$ families (the initial sample size).

Models were run with and without auxiliary predictors of missingness (e.g., single parenthood). There were no substantive differences in our main study findings. Second, all scatterplots of linear relationships were examined, in addition to regression diagnostics (e.g., outliers, high leverage data points). Findings from these analyses suggest that there were not patterns of association that appeared to be truncated, for example, at a 1500g birth weight cut-off, or influenced by extreme values. We also conducted analyses with and without controlling for preterm (continuously and categorically) and pregnancy medical complications, and the results were unaffected by such considerations. Third, in order to assess whether the effects of birth weight (family average, family standard deviation, and child-specific) on sensitivity differed as a function of SES, interaction terms (SES*birth weight) were estimated. None of these terms were significant. We further tested if the within-family findings were the same for older and younger siblings by modeling a birth order*birth weight interaction, which was not statistically significant. Fourth, our findings remained the same if we substituted maternal education in years for our SES composite (income and assets). Fifth, we conducted all analyses using maternal reports of parenting. As others find (Gardner, 2000) our measure of observed sensitivity does not correlate with maternal self-report of positivity ($r = .06, p = .11$). Not surprisingly, we found that our results were specific to observed sensitivity during mother-child interactions.

Discussion

This is the first study to examine the child and contextual determinants of differential maternal sensitivity. Following Belsky's (1984) determinants of parenting model, we considered sibling differences in birth weight as a predictor of differential parenting (both between and within-families). Moreover, we considered the possibility that distal risks (i.e. SES) could impact differential parenting through more proximal predictors (i.e. child effects). In terms of child

influences, mothers tended to be more sensitive with siblings who were heavier at birth (i.e., child-specific differential parenting). This finding is particularly compelling, given that the sibling comparison rules out the possibility that this within-family association is due to unobserved between-family differences (Frisell et al., 2011). Indeed, the utilization of a sibling design adds substantially to determinants of parenting research that has focused historically on one parent-child dyad per family (Browne et al., 2015; Jenkins et al., 2015).

In terms of contextual effects, we found that lower SES families had children with greater absolute differences birth weights, overall. In other words, under low SES settings, siblings were more different in their birth weight. Additionally, mothers whose children were more different in birth weight tended to be more different in parenting, overall (i.e. absolute differential parenting). These associations operated independently of the association between family-average maternal sensitivity, family-average birth weight, and SES. Collectively, findings suggest that social disadvantage augments sibling biological variation, making siblings and their environments more different, while clustering and increasing risk between-families (an issue elaborated below).

Considering sibling differences in birth weight as a determinant of differential parenting is novel given that most research has focused on the *consequences* of differential parenting for behavioural development (Boyle et al., 2004). However, there is evidence to suggest a dynamic interplay between constitutional sibling differences and sibling variability in experiences with parents (Jenkins et al., 2016; Hadd & Rodgers, 2017; Richmond, Stocker, & Rienks, 2005). Indeed, findings from the present study are consistent with bidirectional models of socialization between parents and children (Bell, 1968; Granic & Patterson, 2006; Sameroff, 2010). Sibling differences in the receipt of a particular parenting domain are viewed to be higher under settings

of contextual stress because parental psychological resources are taxed. Consequently, caregivers may find it difficult to allocate equitable amounts of warmth, affection, time, and attention across all children within a family (Henderson et al., 1996; Jenkins et al., 2003). In the present study, the absolute difference in sibling birth weight could potentially operate as a between-family risk. That is, the presence of markedly different children within a family may engender differences in the way parents respond and react to their children. Interestingly, twin comparisons have demonstrated that relatively lower birth weight is causally associated with cognitive and behavioral challenges (Asbury et al., 2006; Stromswold, 2006). Thus, in families where siblings are very different in birth weights, the presence of a child with more difficulties may overburden parents, thereby increasing the likelihood that they treat their children differently, overall.

Patterns of association provide further insight into the nature of the relationship between birth weight and parenting. Sibling comparison studies linking child-specific birth weight and self-reported differential parenting have been equivocal (Hsin, 2012; Lynch & Brooks, 2013). However, by using a more objective observational metric of maternal sensitivity, the present findings suggest that mothers are indeed more sensitive to siblings who are of relatively higher birth weight. Moreover, the employment of a sibling comparison design eliminates the possibility that child-specific findings are attributable to family-level confounds – as the relationship is entirely within families – and reduces the likelihood that results are attributable to a passive gene-environment confound (D’Onofrio et al., 2013; Frisell et al., 2011). In the current study, the sibling comparison component of the model also controlled for a variety of child-specific factors, such as birth order, gender, and preterm status, which further strengthens the conclusion that infant birthweight may be causally related to parental sensitivity.

Children shape their own experiences in part by evoking specific responses from their caregivers in a way that is consistent with their biobehavioral characteristics. Some children elicit more cognitively stimulating responses from parents compared to siblings (Tucker-Drob & Harden, 2012), while others elicit more harshness (Plamondon et al., 2017). Child influences may also occur during earlier periods of development, with more challenging infants evoking more hostility compared to siblings (Boivin et al., 2005). Given that birth outcomes are associated with later biobehavioral development, it is not surprising to find associations between birthweight and parenting (Camerota et al., 2015). Indeed, lower birth weight siblings may be more difficult to read, thereby altering or impacting their caregiver's perception and capacity to respond contingently to infant cues (Feldman, 2006).

It is important to speculate on the mechanisms that account for the association between sibling differences in birth weight and differential maternal sensitivity. Our results are congruent with theories suggesting that parents reinforce children's constitutional endowments with greater resource allocation in order to maximize their child's human capital (Becker & Tomes, 1994). Birth weight may be conceptualized as an indicator of human capital, given its association with health and socioeconomic achievement (Conley & Bennett, 2000), in addition to cognitive and behavioral functioning (Jefferis et al., 2002). Normative variation in birth weight has been linked to neurocognition in domains such as executive functioning, social cognition, and language (Madigan, Wade, Plamondon, Browne, & Jenkins, 2015; Wade et al., 2014). In other words, it is plausible that more advanced children – who have a greater capacity for executive control, interpersonal awareness, communication and regulation – recruit themselves into social exchanges and elicit positive responses from caregivers. Furthermore, one could argue that previous null findings from self-report studies are not entirely surprising given that such metrics

partially reflect parents' attitudes (Gardner, 2000). That is, it is unlikely that parents would consciously appraise a heavier child more favorably, irrespective of more salient explanations. Additionally, it is interesting that both *heavier* siblings and *older* siblings (lower birth order) receive more sensitivity, given that birth weight increases with birth order (Juntunen, Laara & Kauppila, 1997). While these effects were independent, one explanation is that older siblings are more active and engaged during parent-child interactions compared to their younger sibling. Future sibling-comparison research exploring these mechanisms is warranted.

In terms of contextual effects on absolute differential sensitivity, our findings add nuance to studies citing greater differential parenting under settings of low SES (Jenkins et al., 2003; Meunier et al., 2013). Contextual adversity may increase observable sibling differences in development as early as the peripartum period, specifically in the form of birth weight, which is often used as a proxy for quality of fetal environment and biological risk (Asbury et al., 2006; Conley & Bennett, 2000; Jefferis et al., 2002). These differences go on to predict greater sibling differences in the receipt of maternal sensitivity. Complementary findings come from behavioral genetics, whereby the influences of child specific environmental risks on development are augmented in high risk or "extreme" contexts (e.g., impoverished or abusive homes; Plomin, 2011). For example, South & Kruger (2011) demonstrated that there are relatively greater *non-shared* environmental effects for internalizing psychopathology under settings of low SES. That being said, the relative importance of genetic, shared, and non-shared effects depend on a number factors, including developmental age, moderating context, and outcome in question (Lajunen, Kaprio, Rose, Pulkkinen, & Silventoinen, 2012; Legrand, Keyes, McGue, Iacono, & Krueger, 2008; Tuvblad, Grann, & Lichtenstein, 2006). To date, the hypothesis of greater non-shared environmental effects in birth weight under settings of low SES has not been tested while

accounting for genetic effects. While behavioral genetic research has demonstrated greater between-group (i.e., racial) differences in birth outcomes under setting of shared adversity (van Den Oord & Rowe, 2000), the implications for sibling differences remain unclear.

Our findings are in concert with literature citing the protective effects of responsive parenting interventions for children with biological risk based on birth weight variability (Landry et al, 2008), in addition to intervention models that account for influences across the family system (Dishion & Stormshak, 2007). Given that there is substantial similarity in parenting across siblings (Madigan, Plamondon, Browne, & Jenkins, 2016), and clustering in parenting at the family level (Browne et al., 2012), the effects of responsive parenting interventions may spill over into other parent-child dyads in the household. However, as is presently demonstrated, there is also substantial variability in parenting within-families, which is exacerbated under settings of risk (Browne et al., 2015). Accordingly, responsive parenting interventions targeted at mothers in high risk families may be effectively tailored to manage the increased sibling variability in birth weight *and* parenting under conditions of low SES. Indeed, the challenge of parenting is, by and large, augmented in low SES homes, as these mothers are faced with the task of parenting children who are of lower birth weight, overall, and who are increasingly differentiated. Future research should consider the best implementation of responsive parenting interventions, where sensitivity across multiple children-per-family is of particular focus.

Strengths and Limitations

The present study possesses a number of strengths, including the utilization of a prospective birth cohort, longitudinal follow-up, employment of a high-quality observational metric of maternal sensitivity, and multilevel methodology, including a sibling comparison design that controls for between-family background heterogeneity. That being said, there are a

number of limitations that should be considered. First, the absence of a genetically informative design precludes the isolation of genetic effects. Second, the measurement employed in the current study was limited to two children per family. This was largely due to the response burden of observational assessment for mothers and the cost of coding videotaped interactions. Thus, while the multilevel findings are informative, readers should exercise caution in generalizing findings beyond two children per family (though analyses did control for number of children). Relatedly, the purposive nature of the sample may reduce the generalizability of study findings. Participating families included multiparous and English speaking mothers who had children that were greater than 1500g. Compared to the national census, families tended to be of higher SES and were more likely to be intact. In addition to issues pertaining to external validity, the select nature of our sample has implications for internal validity, as well. The associations of study variables (through, for instance, non-linearity or third variable associations), may have differed if VLBW children and more families of low SES had been included. It is possible that the extreme fragility of VLBW children might elicit a different response from parents. Further this response could differ as a function of socioeconomic status (Beaulieu & Bugental, 2008). The selection bias of our sample did not allow such examination but it is important to explore this in future research. Finally, the parenting behavior of mothers was exclusively considered. It is important to remember that parental resource allocation often operates across an entire family system, which may include partners, grandparents, extended family members, and non-biological caretakers. Future studies may consider examining parental resource allocation within the context of broad and eclectic family definitions. In spite of these limitations, the present study represents an important contribution to the study of contextual risk and the augmentation of sibling differences in risk across early life.

References

- Adegboye, A. R. A., & Heitmann, B. L. (2008). Accuracy and correlates of maternal recall of birthweight and gestational age. *BJOG: An International Journal of Obstetrics & Gynaecology*, 115(7), 886-893. doi:10.1111/j.1471-0528.2008.01717.x
- Asbury, K., Dunn, J. F., & Plomin, R. (2006). Birthweight-discordance and differences in early parenting relate to monozygotic twin differences in behaviour problems and academic achievement at age 7. *Developmental Science*, 9(2), F22-F31. doi:10.1111/j.1467-7687.2006.00469.x
- Atzaba-Poria, N., & Pike, A. (2008). Correlates of differential treatment: Parental and contextual factors during middle childhood. *Child Development*, 79(1), 217-232. doi:10.1111/j.1467-7687.2006.00469.x
- Avinun, R., & Knafo, A. (2014). Parenting as a reaction evoked by children's genotype: A meta-analysis of children-as-twins studies. *Personality and Social Psychology Review*, 18(1), 87-102. doi: 10.1177/1088868313498308
- Bauer, D. J. (2003). Estimating multilevel linear models as structural equation models. *Journal of Educational and Behavioral Statistics*, 28(2), 135-167. doi: 10.3102/10769986028002135
- Beaulieu, D. A., & Bugental, D. (2008). Contingent parental investment: An evolutionary framework for understanding early interaction between mothers and children. *Evolution and Human Behavior*, 29(4), 249-255. doi: 10.1016/j.evolhumbehav.2008.01.002
- Becker, G. S., & Tomes, N. (1994). Human capital and the rise and fall of families. In G. S. Becker (Ed.), *Human Capital: A Theoretical and Empirical Analysis with Special*

- Reference to Education (3rd ed.)* (pp. 257-298). Chicago, IL: The University of Chicago Press. doi:10.7208/chicago/9780226041223.001.0001
- Bell, R. Q. (1968). A reinterpretation of the direction of effects in studies of socialization. *Psychological Review*, 75(2), 81-95. doi:10.1037/h0025583
- Belsky, J. (1984). The determinants of parenting: A process model. *Child development*, 83-96. doi: 10.2307/1129836
- Belsky, J. & Jaffee, S. R. (2015) The Multiple Determinants of Parenting. In *Developmental Psychopathology, Second Edition* (eds D. Cicchetti and D. J. Cohen). John Wiley & Sons, Inc., Hoboken, NJ, USA. doi: 10.1002/9780470939406.ch2
- Belsky, J., & Pasco Fearon, R. M. (2002). Early attachment security, subsequent maternal sensitivity, and later child development: Does continuity in development depend upon continuity of caregiving? *Attachment & Human Development*, 4(3), 361-361-387. doi: 10.1080/14616730210167267
- Belsky, J., Pasco Fearon, R. M., & Bell, B. (2007). Parenting, attention and externalizing problems: testing mediation longitudinally, repeatedly and reciprocally. *Journal of Child Psychology Psychiatry*, 48(12), 1233-1242. doi:10.1111/j.1469-7610.2007.01807.x
- Bernier, A., Carlson, S. M., Deschênes, M., & Matte-Gagné, C. (2012). Social factors in the development of early executive functioning: a closer look at the caregiving environment. *Developmental Science*, 15(1), 12-24. doi:10.1111/j.1467-7687.2011.01093.x
- Boivin, M., Pérusse, D., Dionne, G., Saysset, V., Zoccolillo, M., Tarabulsky, G. M., . . . Tremblay, R. E. (2005). The genetic-environmental etiology of parents' perceptions and self-assessed behaviours toward their 5-month-old infants in a large twin and singleton

- sample. *Journal of Child Psychology and Psychiatry*, 46(6), 612-630.
doi:10.1111/j.1469-7610.2004.00375.x
- Boyle, M. H., Jenkins, J. M., Hadjiyannakis, K., Cairney, J., Duku, E., & Racine, Y. A. (2004). Differential Maternal Parenting Behavior: Estimating within and between family effects on children. *Child Development*, 75, 1457-1476. doi:10.1111/j.1467-8624.2004.00751.x
- Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic Status and Child Development. *Annual Review of Psychology*, 53, 235-309. doi:10.1146/annurev.psych.53.100901.135233
- Brooks-Gunn, J., Schneider, W., & Waldfogel, J. (2013). The great recession and the risk for child maltreatment. *Child Abuse & Neglect*, 37(10), 721-729.
doi:10.1016/j.chiabu.2013.08.004
- Browne, D. T., & Jenkins, J. M. (2012). Health across early childhood and socioeconomic status: examining the moderating effects of differential parenting. *Social Science & Medicine*, 74(10), 1622-1629. doi:10.1016/j.socscimed.2012.01.017
- Browne, D. T., Meunier, J. C., O'Connor, T. G., & Jenkins, J. M. (2012). The role of parental personality traits in differential parenting. *Journal of Family Psychology*, 26(4), 542-553. doi:10.1037/a0028515
- Browne, D. T., Plamondon, A., Prime, H., Puente-Duran, S., & Wade, M. (2015). Cumulative risk and developmental health: an argument for the importance of a family-wide science. *Wiley Interdisciplinary Reviews: Cognitive Science*, 6, 397-407. doi:10.1002/wcs.1349
- Burt, S. A., McGue, M., Iacono, W. G., & Krueger, R. F. (2006). Differential parent-child relationships and adolescent externalizing symptoms: Cross-lagged analyses within a monozygotic twin differences design. *Developmental Psychology*, 42, 1289-1298.
doi:10.1037/0012-1649.42.6.1289

Camerota, M., Willoughby, M. T., Cox, M., Greenberg, M. T., & Investigators, F. L. P. (2015).

Executive Function in Low Birth Weight Preschoolers: The Moderating Effect of Parenting. *Journal of Abnormal Child Psychology*, 43(8),1551-1562.

doi:10.1007/s10802-015-0032-9

Catov, J. M., Newman, A. B., Kelsey, S. F., Roberts, J. M., Sutton-Tyrrell, K. C., Garcia, M., . . .

Ness, R. B. (2006). Accuracy and reliability of maternal recall of infant birth weight among older women. *Annals of Epidemiology*, 16(6), 429-431.

doi:10.1016/j.annepidem.2005.09.004

Conley, D., & Bennett, N. G. (2000). Is biology destiny? Birth weight and life chances.

American Sociological Review, 65(3), 458-467. doi:10.2307/2657467

Conger, R. D., Conger, K. J., & Martin, M. J. (2010). Socioeconomic Status, Family Processes, and Individual Development. *Journal of Marriage and Family Therapy*, 72(3), 685-704.

DOI: 10.1111/j.1741-3737.2010.00725.x

Curran, P. J. (2003). Have multilevel models been structural equation models all

along?. *Multivariate Behavioral Research*, 38(4), 529-569. doi:

10.1207/s15327906mbr3804_5

D'Onofrio, B. M., Lahey, B. B., Turkheimer, E., & Lichtenstein, P. (2013). Critical need for family-based, quasi-experimental designs in integrating genetic and social science research. *American Journal of Public Health*, 103(S1), S46-S55.

doi:10.2105/ajph.2013.301252

de Bernabé, J. V., Soriano, T., Albaladejo, R., Juarranz, M., Calle, M. a. E., Martínez, D., &

Domínguez-Rojas, V. (2004). Risk factors for low birth weight: a review. *European*

- Journal of Obstetrics & Gynecology and Reproductive Biology*, 116(1), 3-15.
doi:10.1016/j.ejogrb.2004.03.007
- Deater-Deckard, K., Pylas, M. V., & Petrill, S. A. (1997). *Parent-Child Interaction System (PARCHISY)*. Institute of Psychiatry. London, UK. .
- Dubay, L., Joyce, T., Kaestner, R., & Kenney, G. M. (2001). Changes in prenatal care timing and low birth weight by race and socioeconomic status: implications for the Medicaid expansions for pregnant women. *Health Services Research*, 36(2), 373-398.
- Feinberg, M. E., McHale, S.M., Crouter, A.C. and Cumsille, P. (2003). Sibling Differentiation: Sibling and Parent Relationship Trajectories in Adolescence. *Child Development*, 74(5), 1261-1274. doi:10.1111/1467-8624.00606
- Feldman, R. (2006). From biological rhythms to social rhythms: Physiological precursors of mother-infant synchrony. *Developmental Psychology*, 42(1), 175-188. doi:10.1037/0012-1649.42.1.175
- Feldman, R. (2012). Parent-Infant Synchrony: A biobehavioral model of mutual influences in the formation of affiliative bonds. *Monographs of the Society for Research in Child Development*, 77(2), 42-51. doi:10.1111/j.1540-5834.2011.00660.x
- Feldman, R., Dollberg, D., & Nadam, R. (2011). The expression and regulation of anger in toddlers: Relations to maternal behavior and mental representations. *Infant Behavior and Development*, 34(2), 310-320. doi:10.1016/j.infbeh.2011.02.001
- Feldman, R., & Klein, P. S. (2003). Toddlers' self-regulated compliance to mothers, caregivers, and fathers: implications for theories of socialization. *Developmental Psychology*, 39(4), 680-692. doi:10.1037/0012-1649.39.4.680

- Finch, B. K. (2003). Socioeconomic Gradients and Low Birth-Weight: Empirical and Policy Considerations. *Health Services Research*, 38(6), 1819-1842. doi:10.1111/j.1475-6773.2003.00204.x
- Frisell, T., Öberg, S., Kuja-Halkola, R., & Sjölander, A. (2012). Sibling comparison designs: bias from non-shared confounders and measurement error. *Epidemiology*, 23(5), 713-720. doi: 10.1097/EDE.0b013e31825fa230
- Gardner, F. (2000). Methodological issues in the direct observation of parent–child interaction: Do observational findings reflect the natural behavior of participants? *Clinical Child and Family Psychology Review*, 3(3), 185-198. doi:10.1023/a:1009503409699
- Gass, K., Jenkins, J., & Dunn, J. (2007). Are sibling relationships protective? A longitudinal study. *Journal of Child Psychology and Psychiatry*, 48(2), 167-175. doi:10.1037/e721432007-009
- Gaviria, A. (2002). Intergenerational mobility, sibling inequality and borrowing constraints. *Economics of Education Review*, 21(4), 331-340. doi:10.1016/s0272-7757(01)00031-0
- Gluckman, P., Hanson, M., & Buklijas, T. (2010). A conceptual framework for the developmental origins of health and disease. *Journal of Developmental Origins of Health and Disease*, 1, 6-18. doi:10.1017/s2040174409990171
- Granic, I., & Patterson, G. R. (2006). Toward a comprehensive model of antisocial development: a dynamic systems approach. *Psychological Review*, 113(1), 101-131. doi:10.1037/0033-295X.113.1.101
- Gunning, M., Conroy, S., Valoriani, V., Figueiredo, B., Kammerer, M. H., Muzik, M., . . . Murray, L. (2004). Measurement of mother–infant interactions and the home

- environment in a European setting: preliminary results from a cross-cultural study. *The British Journal of Psychiatry*, 184(46), s38-s44. doi:10.1192/bjp.184.46.s38
- Hadd, A. R., & Rodgers, J. L. (2017). Intelligence, income, and education as potential influences on a child's home environment: A (maternal) sibling-comparison design. *Developmental Psychology*, 53(7), 1286-1299. doi: 10.1037/dev0000320
- Henderson, S. H., Hetherington, E. M., Mekos, D., & Reiss, D. (1996). Stress, parenting, and adolescent psychopathology in nondivorced and stepfamilies: A within-family perspective. In E. M. Hetherington & E. A. Blechman (Eds.), *Advances in family research: Stress, coping, and resiliency in children and families*. Hillsdale, N.J.: Erlbaum. doi:10.4324/9781315806303
- Henry, B., Moffitt, T. E., Caspi, A., Langley, J., & Silva, P. A. (1994). On the "remembrance of things past": a longitudinal evaluation of the retrospective method. *Psychological Assessment*, 6(2), 92-101. doi:10.1037/1040-3590.6.2.92
- Hsin, A. (2012). Is biology destiny? Birth weight and differential parental treatment. *Demography*, 49(4), 1385-1405. doi:10.1007/s13524-012-0123-y
- Hutcheon, J. A., Platt, R. W., Meltzer, S. J., & Egeland, G. M. (2006). Is birth weight modified during pregnancy? Using sibling differences to understand the impact of blood glucose, obesity, and maternal weight gain in gestational diabetes. *American Journal of Obstetrics and Gynecology*, 195(2), 488-494. doi:10.1016/j.ajog.2006.01.107
- Jaffee, S. R., Van Hulle, C., & Rodgers, J. L. (2011). Effects of nonmaternal care in the first 3 years on children's academic skills and behavioral functioning in childhood and early adolescence: A sibling comparison study. *Child Development*, 82(4), 1076-1091. doi:10.1111/j.1467-8624.2011.01611.x

- Jefferis, B. J., Power, C., & Hertzman, C. (2002). Birth weight, childhood socioeconomic environment, and cognitive development in the 1958 British birth cohort study. *British Medical Journal*, 325(7359), 305. doi:10.1136/bmj.325.7359.305
- Jenkins, J. M., McGowan, P., & Knafo-Noam, A. (2016). Parent–offspring transaction: Mechanisms and the value of within family designs. *Hormones and Behavior*, 77, 53-61. doi:10.1016/j.yhbeh.2015.06.018
- Jenkins, J. M., Rasbash, J., & O'Connor, T. G. (2003). The role of the shared family context in differential parenting. *Developmental Psychology*, 39, 99-113. doi:10.1037/0012-1649.39.1.99
- Juntunen, K. S., Läärä, E. M., & Kauppila, A. J. (1997). Grand grand multiparity and birth weight. *Obstetrics & Gynecology*, 90(4), 495-499. doi: 10.1016/S0029-7844(97)00269-X
- Kearney, M. H., Munro, B. H., Kelly, U., & Hawkins, J. W. (2004). Health behaviors as mediators for the effect of partner abuse on infant birth weight. *Nursing Research*, 53(1), 36-45. doi:10.1097/00006199-200401000-00006
- Klahr, A. M., & Burt, S. A. (2014). Elucidating the etiology of individual differences in parenting: A meta-analysis of behavioral genetic research. *Psychological Bulletin*, 140(2), 544-586. DOI: 10.1037/a0034205
- Lahey, B. B., & D'Onofrio, B. M. (2010). All in the family: Comparing siblings to test causal hypotheses regarding environmental influences on behavior. *Current Directions in Psychological Science*, 19(5), 319-323.
- Lajunen, H. R., Kaprio, J., Rose, R. J., Pulkkinen, L., & Silventoinen, K. (2012). Genetic and environmental influences on BMI from late childhood to adolescence are modified by parental education. *Obesity*, 20(3), 583-589. doi:10.1038/oby.2011.304

- Legrand, L., Keyes, M., McGue, M., Iacono, W., & Krueger, R. (2008). Rural environments reduce the genetic influence on adolescent substance use and rule-breaking behavior. *Psychological Medicine*, 38(09), 1341-1350. doi:10.1017/s0033291707001596
- Ludwig, D. S., & Currie, J. (2010). The association between pregnancy weight gain and birthweight: a within-family comparison. *The Lancet*, 376(9745), 984-990. doi:10.3410/f.10972956.11909055
- Lunde, A., Melve, K. K., Gjessing, H. K., Skjærven, R., & Irgens, L. M. (2007). Genetic and environmental influences on birth weight, birth length, head circumference, and gestational age by use of population-based parent-offspring data. *American Journal of Epidemiology*, 165(7), 734-741. doi:10.1093/aje/kwk107
- Lynch, J. L., & Brooks, R. (2013). Low Birth Weight and Parental Investment: Do Parents Favor the Fittest Child? *Journal of Marriage and Family*, 75(3), 533-543. doi:10.2139/ssrn.2143206
- Madigan, S., Plamondon, A., Browne, D., & Jenkins, J. (2016). Stability of Observed Maternal Behavior Across Time, Tasks and Siblings. *Parenting: Science and Practice*, 16(2), 108-124. doi:10.1080/15295192.2016.1134990
- Madigan, S., Wade, M., Plamondon, A., Browne, D., & Jenkins, J. M. (2015). Birth weight variability and language development: Risk, resilience, and responsive parenting. *Journal of pediatric psychology*, 40(9), 869-877.
- Matias, C., Scott, S., & O'Connor, T. G. (2006). (2006). *Coding of Attachment-Related Parenting (CARP)*. Institute of Psychiatry, King's College London, UK.
- Mehta, P. D., & Neale, M. C. (2005). People are variables too: Multilevel structural equations modeling. *Psychological methods*, 10(3), 259-284. doi: 10.1037/1082-989X.10.3.259

- Meunier, J. C., Bisceglia, R., & Jenkins, J. M. (2012). Differential parenting and children's behavioral problems: Curvilinear associations and mother–father combined effects. *Developmental Psychology*, 48(4), 987-1002. doi:10.1037/a0026321
- Meunier, J. C., Boyle, M., O'Connor, T. G., & Jenkins, J. M. (2013). Multilevel Mediation: Cumulative Contextual Risk, Maternal Differential Treatment, and Children's Behavior Within Families. *Child Development*, 84(5), 1594-1615. doi:10.1111/cdev.12066
- Muthen, L. K., & Muthen, B. O. (1998-2010). Mplus User's Guide. Sixth Edition. . Los Angeles, CA. : Muthen & Muthen.
- NICHD (2001). Child-Care and Family Predictors of Preschool Attachment and Stability from Infancy. *Developmental Psychology*, 37(6), 847-862. doi:10.1037/0012-1649.37.6.847
- NICHD (1999). Chronicity of Maternal Depressive Symptoms, Maternal Sensitivity, and Child Functioning at 36 Months. *Developmental Psychology*, 35(5), 1297-1310. doi:10.1037/0012-1649.37.6.847
- Plamondon, A., Browne, D. T., Madigan, S., & Jenkins, J. M. (2017). Disentangling child-specific and family-wide processes underlying negative mother-child transactions. *Journal of abnormal child psychology*, 1-11. doi: 10.1007/s10802-017-0309-2
- Plomin, R. (2011). Commentary: Why are children in the same family so different? Non-shared environment three decades later. *International Journal of Epidemiology*, 40(3), 582-592. doi:10.1093/ije/dyq144
- Repetti, R., Wang, S.W., & Saxbe, D. (2009). Bringing It All Back Home How Outside Stressors Shape Families' Everyday Lives. *Current Directions in Psychological Science*, 18(2), 106-111. doi:10.1111/j.1467-8721.2009.01618.x

- Richmond, M. K., Stocker, C. M., & Rienks, S. L. (2005). Longitudinal associations between sibling relationship quality, parental differential treatment, and children's adjustment. *Journal of Family Psychology, 19*(4), 550-559. doi:10.1037/0893-3200.19.4.550
- Sameroff, A. (2010). A unified theory of development: A dialectic integration of nature and nurture. *Child development, 81*(1), 6-22. doi:10.1111/j.1467-8624.2009.01378.x
- Sethre-Hofstad, L., Stansbury, K., & Rice, M. A. (2002). Attunement of maternal and child adrenocortical response to child challenge. *Psychoneuroendocrinology, 27*(6), 731-747. doi:10.1016/s0306-4530(01)00077-4
- South, S., & Krueger, R. (2011). Genetic and environmental influences on internalizing psychopathology vary as a function of economic status. *Psychological Medicine, 41*(1), 107-117. doi:10.1017/s0033291710000279
- Stromswold, K. (2006). Why aren't identical twins linguistically identical? Genetic, prenatal and postnatal factors. *Cognition, 101*(2), 333-384. doi:10.1016/j.cognition.2006.04.007
- Tucker-Drob, E. M., Rhemtulla, M., Harden, K. P., Turkheimer, E., & Fask, D. (2011). Emergence of a gene \times socioeconomic status interaction on infant mental ability between 10 months and 2 years. *Psychological Science, 22*(1), 125-133. doi: 10.1177/0956797610392926
- Tucker-Drob, E. M., & Harden, K. P. (2012). Early childhood cognitive development and parental cognitive stimulation: evidence for reciprocal gene–environment transactions. *Developmental Science, 15*(2), 250-259. doi:10.1111/j.1467-7687.2011.01121.x
- Turkheimer, E., & Waldron, M. (2000). Nonshared environment: A theoretical, methodological and quantitative review. *Psychological Bulletin, 126*, 78-108. doi:10.1037//0033-2909.126.1.78

- Tuvblad, C., Grann, M., & Lichtenstein, P. (2006). Heritability for adolescent antisocial behavior differs with socioeconomic status: gene–environment interaction. *Journal of Child Psychology and Psychiatry*, 47(7), 734-743. doi:10.1111/j.1469-7610.2005.01552.x
- van Den Oord, E. J., & Rowe, D. C. (2000). Racial differences in birth health risk: A quantitative genetic approach. *Demography*, 37(3), 285-298. doi: 10.2307/2648042
- Wade, M., Browne, D. T., Madigan, S., Plamondon, A., & Jenkins, J. M. (2014). Normal birth weight variation and children's neuropsychological functioning: links between language, executive functioning, and theory of mind. *Journal of the International Neuropsychological Society*, 20(9), 909-919. doi: 10.1017/S1355617714000745
- Walton, K., Murray, L., Gallagher, A., Cran, G., Savage, M., & Boreham, C. (2000). Parental recall of birthweight: a good proxy for recorded birthweight? *European Journal of Epidemiology*, 16(9), 793-796. doi:10.1023/a:1007625030509

Table 1

Child-Specific and Family-Average Descriptive Statistics and Variable Intercorrelations

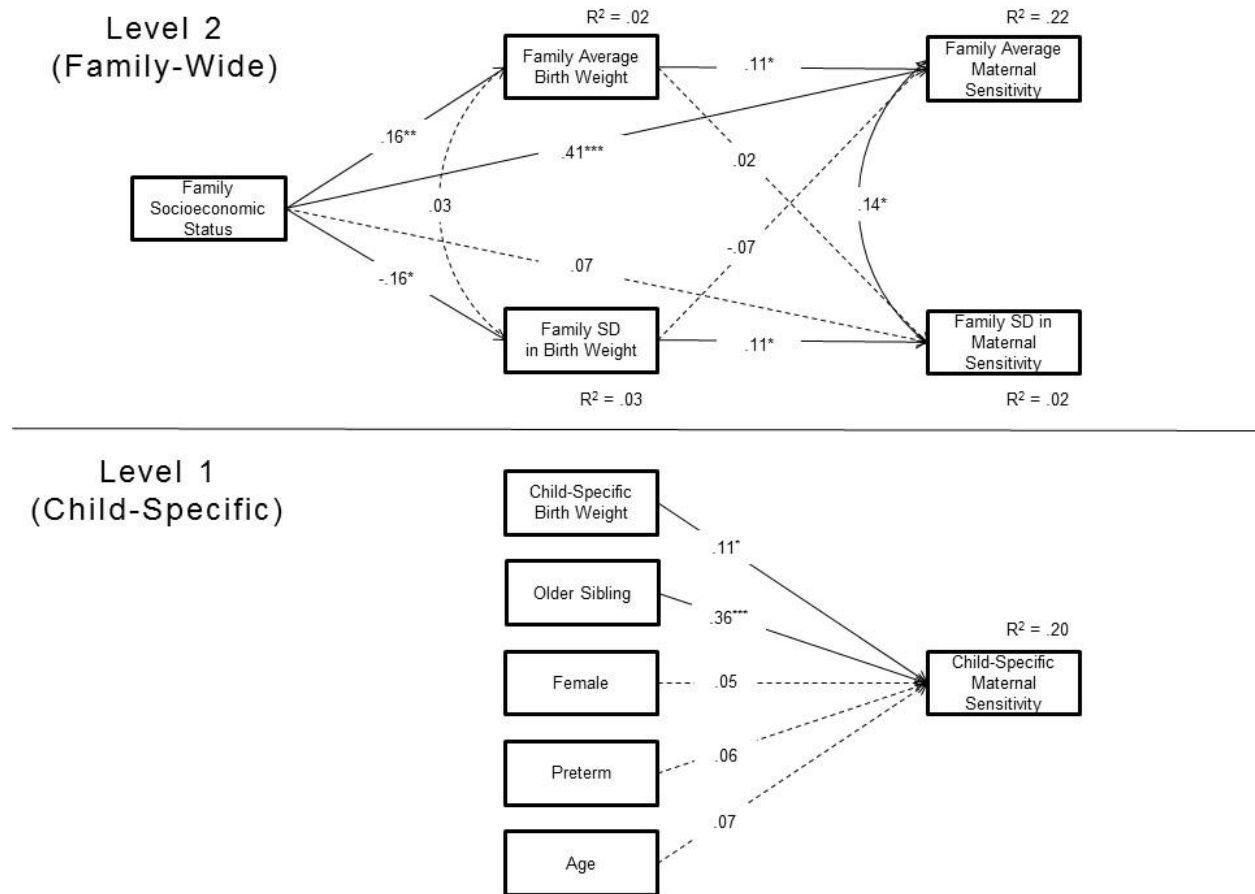
	2	3	4	5	<i>M</i>	<i>SD</i>	N ^b	missing n (%)
<i>Child-Specific</i>								
1 Birth Weight (kg)	.15**	-.36**	-.14**	-.05	3.42	0.52	--	93 (12%)
2 Sensitivity (1-5)		.01	.05	.26**	3.73	0.84	--	46 (6%)
3 Preterm ^a			--	--	--	--	29 (4%)	0 (0%)
4 Girl ^a				--	--	--	380 (48%)	0 (0%)
5 Birth Order ^a					--	--	397 (50%)	0 (0%)
	2	3	4	5	<i>M</i>	<i>SD</i>	N ^c	missing n (%)
<i>Family-Average</i>								
1 SES (Z-Score)	.15**	.44**	-.16**	.06	0.18	0.77	--	0 (0%)
2 Birth Weight		.10**	.00	.04	3.42	0.43	--	0 (0%)
3 Sensitivity			-.12	.14**	3.73	0.68	--	19 (5%)
4 SD Weight				.09	0.31	0.31	--	93 (23%)
5 SD Sens.					0.55	0.45	--	19 (5%)

* $p < .05$, ** $p < .01$. kg = kilograms.

^a Pearson correlations are not computed amongst these dichotomous variables. Chi square tests of independence did not reject the null hypothesis that these variables are independent (i.e. they were not significantly related).

^b Total N for child-specific level is 792 children

^c Total N for family-average is 396 families.



* $p < .05$, ** $p < .01$, *** $p < .001$

Note. Level 2 (Family-Wide/Between-Family) and Level 1 (Child-Specific/Within-Family) portions of the model were fit simultaneously using multilevel path analysis. Solid lines indicate statistically significant associations at $p < .05$, while dotted lines are $p \geq .05$.

Figure 1. Multilevel path analysis with standardized coefficients highlighting the associations between family socioeconomic status, birth weight and maternal sensitivity

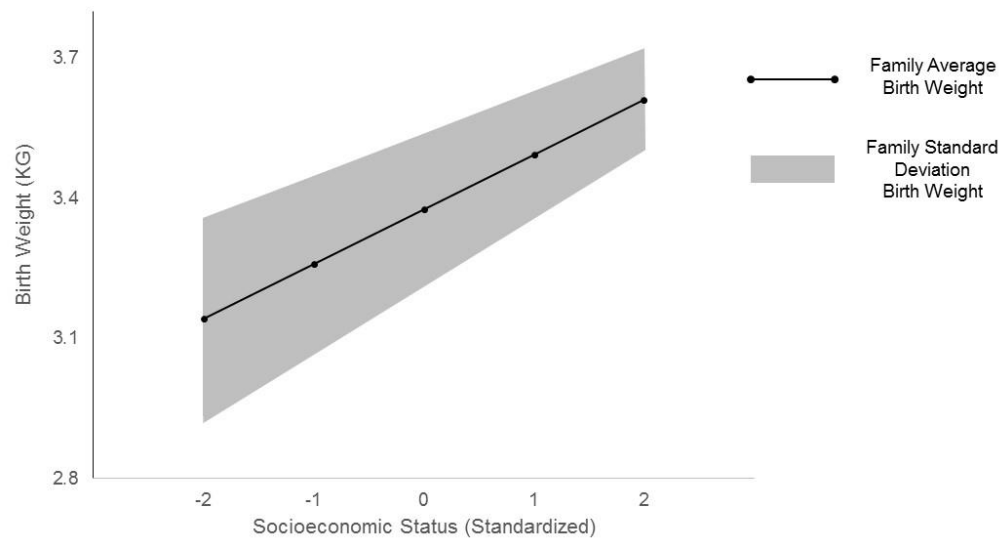
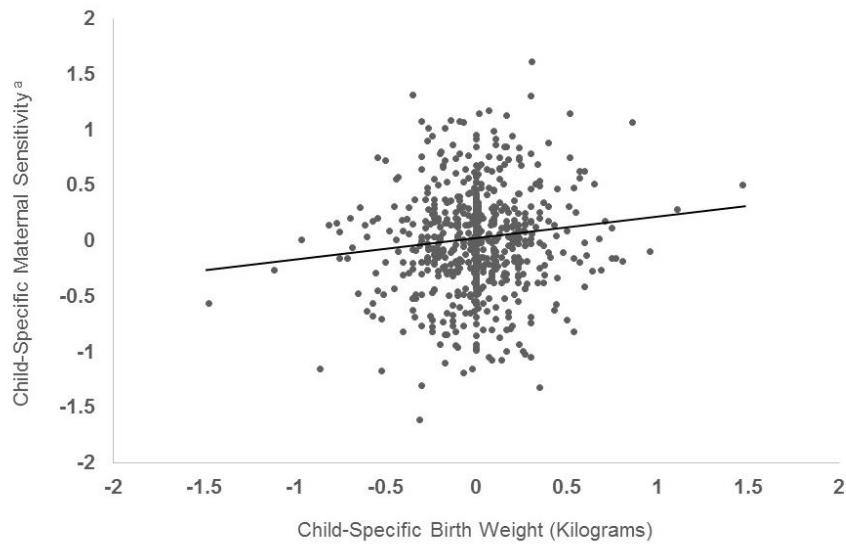


Figure 2. Higher socioeconomic status is associated with higher family-average birth weight and lower within-family variability in birth weight.



^a Y-axis reflects child-specific maternal sensitivity (deviation from family mean), adjusting for birth order, gender, age and preterm status.

Figure 3. Partial plot of the within-family associations between child-specific birth weight and child-specific maternal sensitivity, adjusting for covariates.